A Ticking Time Bomb: Is the illegal pet trade a pathway for the establishment of Corn Snake (*Elaphe guttata*) populations in Australia?

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ABSTRACT

The exotic pet trade may be the principal mechanism for the establishment of invasive reptile species. The escape or deliberate release of captive reptiles has resulted in the establishment of many species globally. In Australia, exposure to this entry pathway has been limited due to long-term legislation preventing the importation and keeping of exotic reptiles by private keepers. Despite this, the corn snake *Elaphe guttata* is still illegally maintained in many private collections, resulting in occasional reports of released or escaped specimens. We recorded 79 free-ranging corn snakes captured by three wildlife organizations between 2002 and 2014 in the greater Sydney region, Australia. There was an increasing encounter rate over time, suggesting that this is a growing problem and may result in the establishment and spread of this species into Australia. Corn snakes were recorded throughout the Sydney region. No snake clusters were found and this suggests that populations may not have become established in the wild yet.

Key words: Corn snake, *Elaphe guttata*, snake invasion, Australia, pet trade

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Introduction

The exotic pet trade may be the main pathway for the introduction and establishment of invasive reptiles globally (Kraus 2009). In Australia, reptile entry via this pathway has been relatively constrained due to long-running, strict legislation prohibiting the importation and private keeping of exotic reptiles. To date, only one species of exotic reptile has established populations in Australia that have been attributed to the keeping of exotic species. The red-eared slider (*Trachemys scripta elegans*) was available in the pet trade in Australia until the early 1960's, and today wild populations are established in Queensland and New South Wales (Robey *et al.* 2011).

Worldwide, there have been numerous examples of exotic snakes establishing sustainable populations (Rodda and Savidge 2007; Kraus 2009). Many invasive snake populations have been attributed to the escape or release of captive animals, including Burmese pythons (*Python molurus bivittatus*) in Florida (Willson *et al.* 2007), California kingsnakes (*Lampropeltis getula californiae*) on Gran Canaria (Monzón-Argüello *et al.* 2015) and boa constrictors (*Boa constrictor*) in Florida (Snow *et al.* 2007), Aruba Island (Quick *et al.* 2005) and Puerto Rico (Reynolds *et al.* 2013).

The Corn Snake (*Elaphe guttata*) is a species native to the south-eastern region of the United States and has been distributed to many parts of the world for the pet trade because of its attractive colours, small size and ease of keeping (Figure 1). It has become established as an invasive species in many parts of the Caribbean, including St Thomas in the Virgin Islands (Perry *et al.* 2003), the Cayman Islands (Franz *et al.* 1987), Grand Bahama Island (Buckner and Franz 1994; Lee 2005) and a small number of other islands (Giery 2013). Little has been recorded on the ecological impacts of invasion by this species, though they have been listed as a significant threat to the Brown-headed Nuthatch (Sitta pusilla) on Grand Bahama Island (Hayes *et al.* 1994).

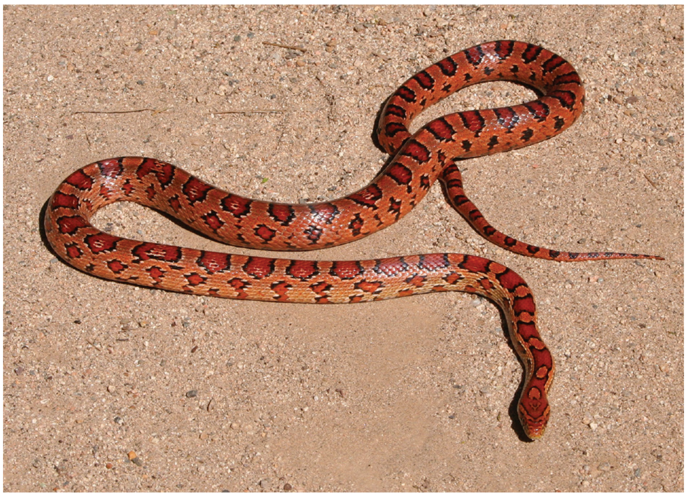


Figure 1. Photo of a Corn Snake *Elaphe guttata* (photo: Annette Peterson).

Despite it being illegal to privately import or keep exotic reptiles in Australia, corn snakes are still commonly held as pets (Henderson *et al*. 2011). However, there has been no confirmed evidence of established populations or breeding in the wild. To date, only 7 specimens in 6 separate incidents have been 'officially' recorded outside of captivity, with these all occurring in Queensland and Victoria (Henderson and Bomford 2011). Our objectives in this study were to: (1) locate unrecorded data on free living corn snakes captured in the Sydney region, and (2) investigate if there are trends or clusters in records indicative of the presence of an established population. In doing so, we aim to identify whether private ownership of corn snakes in the Sydney region provides a potential pathway for the entry and establishment of this species in the wild.

Methods

Our study was confined to the greater Sydney region, in New South Wales, Australia. The state of NSW has over 21,500 licensed pet reptile keepers (licensed to keep Australian native species only), however the number of illegal, exotic reptile keepers is not known. Only records within the Sydney basin were included in this study, as records collected from organizations outside of this area were either not detailed or not accessible.

Data were obtained from three sources during the period from 2002 until 2014. Two of these were wildlife rescue organizations, where records were obtained from staff and volunteers who catch and remove problem snakes. Thirty-nine and twenty-seven records were obtained from the Wildlife Information and Rescue Service (WIRES) and Sydney Metropolitan Wildlife Service, respectively. The third organization was Taronga Zoo, where staff recorded thirteen events where they were contacted by residents to identify reptiles photographed on their properties or had an injured specimen delivered to the zoo. Only records where identification could be verified by the authors from photographs or by direct inspection of the snake by an experienced wildlife carer were accepted.

Data on temporal patterns in encounter rate was analysed utilizing MINITAB. Encounter data followed a normal distribution. A Pearson's correlation analysis was undertaken to examine the relationship between year and the number of corn snake encounters.

Results

Between 2002 and 2014, 79 corn snakes were reported, located and identified by these three organizations within the Sydney region. All corn snakes were encountered in a 'wild state', meaning that the snake was found uncontained and it was not previously kept by the person reporting the nuisance snake. On most occasions, the snakes were found in the garden or under items in the yard of the resident, within a shed or garage on their property or on two occasions, the snake was observed on a road. Corn snakes were recorded in all years, excluding 2003, and demonstrate an increasing trend in occurrence, with a significant positive correlation between encounter rate and year (Pearson $r = 0.933$, $p < 0.0001$) (Figure 2).

Corn snake records were distributed widely throughout the Sydney region (Figure 3), with no distinct cluster of

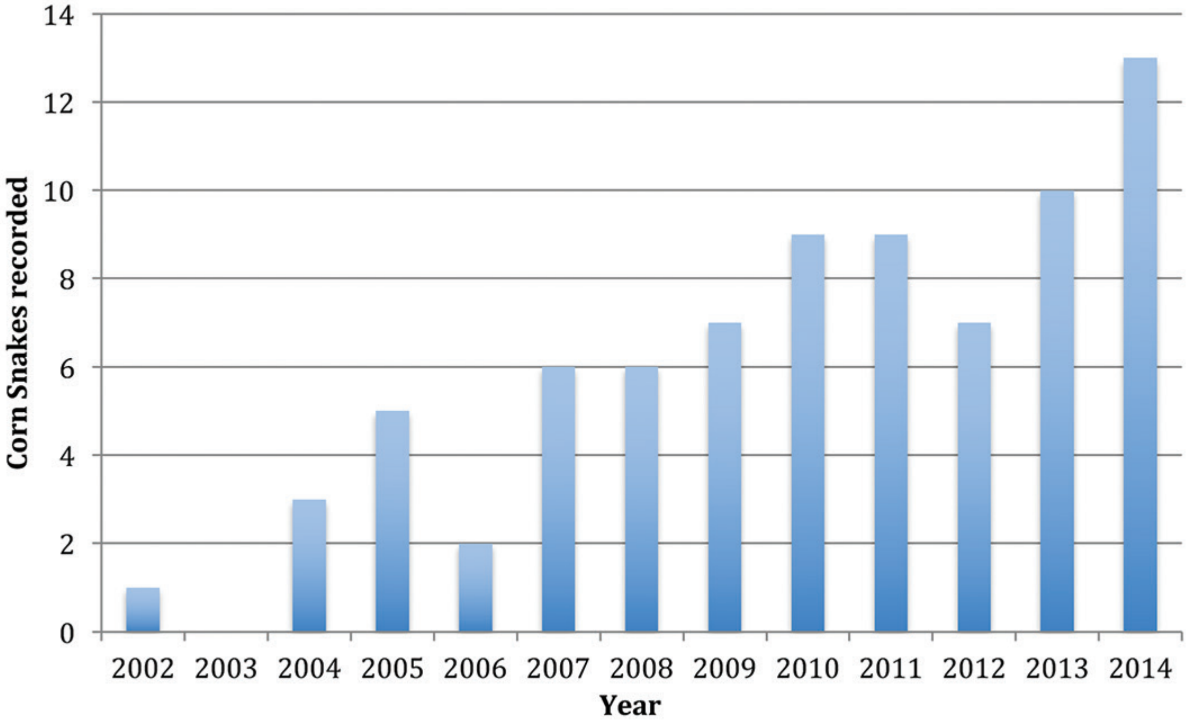
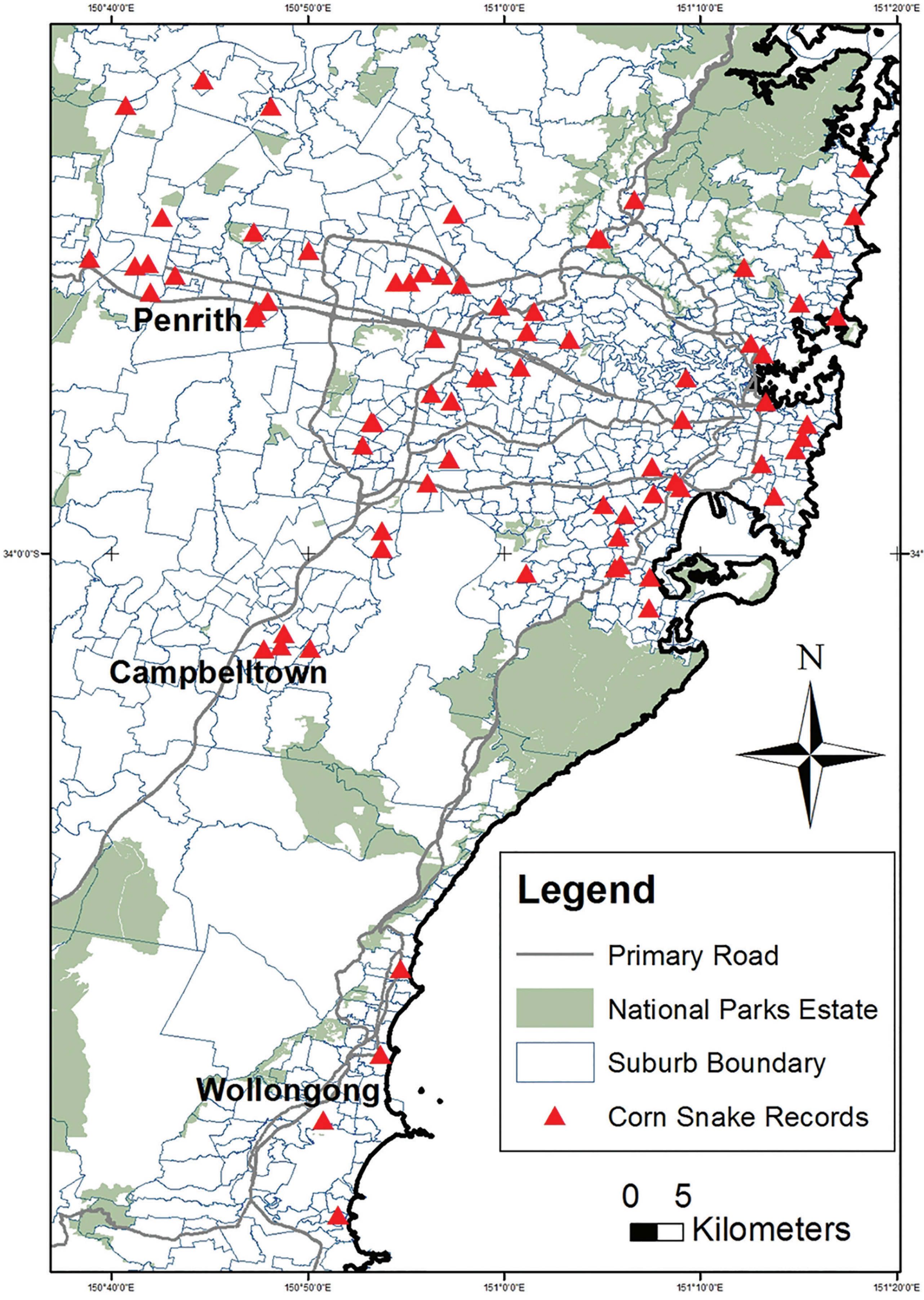


Figure 2. Corn Snakes located within the Sydney region between 2002 and 2014.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Primary Road
National Parks Estate
Suburb Boundary
Corn Snake Records
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Figure 3. Map of the Sydney region, indicating where corn snakes were encountered.

records. Ten suburbs had two records, and none had three or more. Only nine snakes were recorded within 200 m of bushland. Data were not consistently recorded on the sex or age of the snakes captured.

Discussion

This survey demonstrates that corn snakes are being kept illegally in Sydney, that the escape or release of this species from captivity is a relatively frequent event and that they can survive as escaped animals in the wild. Thus, the private keeping of corn snakes could provide a pathway for the potential establishment of this species within the Sydney region. We recorded 79 cases of corn snakes being encountered in residential properties over a 13 year period. We have no evidence that this snake could arrive via any other pathway, such as cargo stowaway or nursery trade. This implies that entry into Australia by accidental means is very unlikely.

Alarmingly, this study provides evidence of a previously unknown and significantly increasing trend in corn snake encounters, suggesting this is an escalating potential threat. Prior to 2002, there were no reliable reports of corn snakes detected in the wild in the Sydney region. Between 1989 and 1998, Sydney wildlife carers reported processing a total of 10,862 individuals of native species, however no exotic species were recorded (Shine and Koenig 2001), though this does not necessarily mean that exotic species weren't encountered. The rising number of encounters in the last 20 years is concerning as the establishment of an invasive species is directly proportional to the number of specimens that enter the environment (Kraus 2009). Single or isolated occurrences of free living individual corn snakes are unlikely to establish populations without a mate, unless they are gravid at the time of escape or release. Despite the low risk, this species can establish from a small founder base: the population in the Cayman Islands is believed to have developed from a single clutch of eggs (Lever 2003). Thus, the increasing number of free-ranging corn snake records increases the likelihood for an individual snake to encounter a potential mate, be a gravid female, or of multiple specimens escaping or being released at a single locality.

It is not possible to confirm if the captive corn snake population is increasing, though the results of this study suggest that this may be true. The only figures currently available are those obtained from occasional seizures of private collections. Between 1999 and 2010, 158 Corn Snakes and 16 eggs were seized or surrendered from illegal private collections in 51 separate incidents throughout Australia (Henderson and Bomford 2011). During that same period, an additional 29 specimens were intercepted at the national border (Henderson and Bomford 2011). Despite it being illegal to import or keep exotic snakes, there is often little deterrent to prevent these activities due to the low rate of detection and prosecution, and unsubstantial penalties (Alacs and Georges 2008). In NSW the maximum penalty for keeping exotic snakes is a fine of up to A$110,000 or five years jail. However, such severe penalties are rarely applied, and most convicted exotic snake keepers face fines of between A$3,000-$6,000.

Although our results demonstrate that corn snakes are being encountered throughout the Sydney region, no hotspots were highlighted suggesting an established population. The widespread distribution of encounters is likely due to repeated escapes or releases from many captive collections, rather than any establishment of the species in the wild. Though clusters of records were not recorded, there were ten suburbs that recorded two specimens. It cannot be ruled out however, that wild populations have already established, as the incidence of our records may not be sufficient to demonstrate a pattern or a hotspot. During the initial establishment phase of biological invasions, the detection rate is often low, with reliable detections not apparent until the species is well established (Kraus 2009). With the increasing numbers of this species being detected in the Sydney environs, it may become possible in future years to detect invasive populations through wildlife rescue and snake relocation organizations. However the records from the growing number of such organizations are not always clearly recorded, easily available or centrally located.

The number of free living corn snake encounters reported in this study is likely to be a large underestimate for the Sydney region. This is due to the relatively shy and secretive nature of this mostly nocturnal species (Ernst and Ernst 2003). It is also unlikely that this study would detect any corn snakes that are present in bushland outside or adjacent to residential areas. Additionally, the organizations surveyed during this study represent only a small proportion of those regularly called upon to remove nuisance snakes. There are also many private licensed snake removers within the Sydney region who informed us that they occasionally encounter corn snakes, though many did not keep accurate records. This highlights a need for a central database to be established to record all incidences of exotic reptile incursions. The lack of a central reporting system results in records not being adequately captured and may hamper the early detection of an established population.

Corn snakes have previously demonstrated that they have the potential to become a successful invasive species if provided a pathway to the natural environment. They have recently become established on numerous islands throughout the Caribbean with most introductions attributed to the pet trade or stowaways in landscaping plants and building materials (Giery 2013). A number of life history attributes are likely to have led to their success as an invasive in this region, including suitable climate, limited predation, their catholic diet and their use of a variety of habitats and disturbed environments, including agricultural and suburban areas (Mehrtens 1987; Giery 2013). The small island environments they have colonized also present limited predation and a lack of competition from similar species, allowing easier establishment.

Two previous risk assessments undertaken on the potential for corn snakes to become an invasive species in Australia have identified the species as a serious or moderate establishment risk (Page *et al.* 2008; Fisher and Csurhes 2009). These assessments were undertaken utilizing both the reptile and amphibian model and the bird and mammal model developed by Bomford (2008). Climatic modeling demonstrated suitable zones based on temperature and precipitation data in the south-west temperate region and along eastern and south-eastern Australia, including the Sydney region (Page *et al.* 2008). Throughout these regions, there are a variety of habitats that would be suitable for corn snake establishment. Additionally, prey availability is not limited, as their diet is quite variable and adaptable, including rodents, rats, birds and lizards, with young corn snakes also accepting frogs and insects (Mehrtens 1987). However, unlike island environments that this species has previously successfully established, Australia has a diversity of snake species that could possibly predate on or fill a similar niche to the corn snake. Australian native snakes may assist in providing some form of control on corn snake populations but would not necessarily preclude their establishment. Thus, if provided with the continual pathway of introduction reported in this study, there is a considerable risk of establishment of free-range corn snake populations in Australia.

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